Appendix A: Peak natural gas production prospects for North America

There is a heated debate among energy analysts, geologists, and economists about the future rates of production for world oil and North American natural gas. This debate can simplistically be described as one between optimists and pessimists.[1] The pessimists are proponents of an imminent peak in oil or natural gas production. Optimists tend to think that technology, human ingenuity, and price signals will allow us to produce enough oil and natural gas for several decades into the future. The outline of each group's argument, particularly as they apply to North American natural gas production, are set out below.

Pessimists

Cumulative natural gas production for the United States at the end of 2003 was approximately 1,050 Tcf, and by 2010 can be expected to be approaching 1,200 Tcf or approximately the same volume as the present technically recoverable natural gas resource base. Current cumulative production slightly exceeds the commercially available resource estimate of 800 to 1,000 Tcf made using recent elevated gas prices.[2] The pessimists have generally argued that geological conditions determine a resource's future production profile and that when the cumulative oil or gas production volume approaches the estimated technical resource volume (cumulative production = estimated remaining resource), the opportunity for incremental production growth rapidly diminishes, and production from the resource will briefly plateau, then begin to decline. King Hubbert, a Shell Oil Company geoscientist, the most famous of the pessimists, formalized the concept of predicting peak production for a finite energy resource such as oil or natural gas. Hubbert used adjusted U.S. oil reserve addition data for the Lower 48 to estimate the total oil resource size at 170 billion barrels and then fit U.S. production data to a logistic, or bell shaped curve. He used this reserve and production information to predicted the 1970 peak and subsequent decline of U.S. oil production (Hubbert, 1962). His attempts to predict the peak U.S. natural gas production were largely unsuccessful.[3]

The concept of a near-term peak, or plateau, in North American natural gas production has emerged with the flat U.S. production of the last several years, two recent price spikes, and the weak production response to high levels of drilling activity in 2001 and 2003. The factors that argue for North American natural gas reaching a production peak in the next several years are laid out below:

1. U.S. natural gas production has been stuck at around 19 Tcf per year for the last seven years, despite indications since the late 1990s that gas demand,

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[1] Sometimes the debate is simplistically framed as one between economists (optimists) and geologists (pessimists).

[2] At a long-term Henry Hub price of $4.50/MMBtu, just over 800 Tcf is commercially available in the Lower 48 region, assuming advanced (2015) technology. Alaska has approximately 100 Tcf commercially available under the same conditions.

[3] Hubbert predicted a 1975 natural gas production peak of 14 Tcf per year. In 2001, gas production was 19.7 Tcf.

particularly in the electricity generation sector, was increasing. Increased drilling activity has had only a minimal effect on production.

2. The basins with large easy to extract natural gas are mature and, for the most part, beginning to decline in productivity. There are only two significant new basins (Rocky Mountain region, and deepwater Gulf of Mexico) that must offset declines in several large older resource basins.
3. Recent production forecasts rely on unconventional resources and frontier natural gas, which because of high costs and significant infrastructure requirements may not be developed rapidly or as extensively.
4. The prospect of affordable LNG (delivered at $3 to $4/MMBtu) might diminish the near-term incentive for energy companies to develop more expensive and risky unconventional and Arctic gas resources in North America.[4]
5. Hubbert was correct about the peaking of U.S. oil production – high prices, development of frontier resources, and better exploration and extraction technology during the 1970s and '80s slowed, but did not stop the decline in U.S. oil production.

Hubbert's bell shaped production curve has frequently been criticized for being a simplistic static model, which is incapable of capturing the dynamic nature of the energy markets. Some of the criticism is well founded, the idealized bell shaped production curve does not readily incorporate technological changes,[5] nor does it lend itself to the sudden shifts in supply, demand, and price that have characterized energy markets. However, the bell shaped production curve does capture a few critical concepts of the development of a finite energy resource. For crude oil and natural gas, the large high productivity fields or basins are discovered and exploited first. These large accumulations produce substantial quantities of oil and gas at low prices for a long period of time. As the large fields and basins are eventually depleted, progressively smaller and more numerous resources typically replace them. The smaller fields and basins have higher extraction costs and cannot individually match the flow or extraction rates of the larger fields, and consequently many more wells must be drilled, raising production costs significantly.

Optimists

Optimists point to the large remaining resource estimates for world oil and North American natural gas, annual reserve and resource additions that exceed annual consumption, and the potential for technology to open up additional resources. The optimists tend to believe in markets and that price signals will not only increase supply, but also modify demand growth.[6] The optimists tend to focus on the series of bad predictions made by the pessimist camp, and their tendency to revise peak production dates out and production volumes upward.

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[4] This is the "throwing in the towel" argument.

[5] When Hubbert made his prediction for peak natural gas production he did not know about new technology that would make deepwater and unconventional natural gas economical.

[6] The optimists also rely heavily on fuel substitution, for example coal, nuclear and renewable energy resources can, over the long run, replace oil or natural gas consumption.

The optimists believe that peak production will occur in the world oil and North American natural gas markets, but that the peak is years away, will be gradual, and that we will transition to new resources when the time comes. They observe that in general energy resource extraction does not follow a (Hubbert) bell shaped production curve, unless the resource is extracted during a period of relatively stable economic growth and energy prices, as was the case with U.S. Lower 48 oil production from 1940-1973. A key reason why U.S. oil production did follow the Hubbert curve was that cheap imported oil kept a lid on prices in the United States starting in the mid 1960s.[7] After 1973, world oil prices rose dramatically and U.S. production began to significantly diverge from the bell shaped production curve, though it never again achieved the production level of 1970. The reasons supporting the optimist's position are state below:

1. Reserve and resource additions have exceeded natural gas production over most of the last decade.
2. Proven reserves are low because businesses, as a prudent practice, reduce their capital costs by producing from only the minimum amount of proven reserves.
3. Technology improvements will make even more unconventional or remote gas resources available in the future.
4. Predictions of a "Hubbert's peak" for North American natural gas and for other oil producing regions have proven inaccurate.
5. Recent natural gas demand growth forecasts may have been too bullish. A moderating economy and higher short-term prices may stimulate efficiency and encourage development of other resources, lessening the rate at which we need to develop our natural gas resource.

Conclusions

Our review of recent natural gas resource and production studies and forecasts for the United States and Canada have led us to conclude that a peak in North American gas production is at least several years off. However, we have consumed much of the "low hanging fruit" of the North American natural gas resource and new resources will be significantly more expensive to develop. An incremental increase in gas production of 10 percent during the time frame from 2004 to 2015 appears possible if the following circumstances are present:

1. Higher gas prices continue through the time frame;
2. Known arctic resources are rapidly developed;
3. Access restrictions on some public lands are eased;
4. And elevated levels of exploration and drilling activity are maintained.

Further gains in U.S and Canadian production seem unlikely as much of the undiscovered or undeveloped North American gas resource is either unconventional in nature, lies in restricted access areas, or is in very remote Arctic frontier regions, and thus cannot be brought to market quickly or economically. Supply constraints and continued strong

[7] From the 1950s to 1970 U.S. oil prices declined by 25 percent in real terms, which discouraged exploration and development.

demand for natural gas will keep supply and demand in tight balance and creating upward pressure on prices. During the next 10 years, LNG, energy efficiency, and renewable energy sources will play initially small, but increasingly important rolls in balancing North American gas supply and demand, and thereby maintaining reasonable gas prices for consumers.